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Indian Standard

CODE OF PRACTICE FOR THE APPLICATION OF POLYURETHANE INSULATION BY THE *IN-SITU* POURING METHOD

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BUREAU OF INDIAN STANDARDS
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NEW DELHI 110002

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Thermal Insulation Materials Sectional Committee, CHD 27

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Thermal Insulation Materials Sectional Committee had been approved by the Chemical Division Council.

Rigid polyurethane foam is a high efficiency thermal insulation material suitable for use on surfaces operating within the temperature range of – 180°C to + 110°C.

Some conspicuous features of *in-situ* polyurethane foam insulation are:

a) The component raw materials are in liquid form which are relatively stable by themselves and afford acceptable shelf life; and

b) The process of manufacture does not involve application of external heating or development of high temperatures in the enclosure where the material is getting formed as *in-situ* insulation.

With the above features, polyurethane lends itself to formation to any shape by its capacity to fill in void pockets of the desired shapes before becoming rigid. This is exploited in the manufacturing processes in the plant to produce moulded products. The same feature is exploited in foamed-*in-situ* method of insulation also. This method is also known as "foam-on-foam" or "layer-on-layer" application method.

This technique is a preferred method adopted for many thermal insulation applications, such as for process plants, piping and other equipment for the range of operating temperatures stipulated above. *In-situ* foaming is particularly suited:

a) Where complicated shapes are involved which would not lend themselves to easy insulation treatment using preformed rigid materials;

b) Where a joint-free insulation is desired or where the number of joints is to be kept to a minimum; and

c) Where very high disbonding stresses (such as leeward wind forces) are to be countered by the insulation system.

Though this method of insulation can be extremely efficient and cost-effective, it involves carrying out a foaming at site, often under difficult site conditions. Hence, there is need for use of proper equipment alongwith adequate inspection as well as collection and testing of regular test sample from various stages during the actual foaming operation, to ensure that the same degree of quality control is obtained as in the case of preformed insulation materials.

The purchaser is advised to satisfy himself that the contractor is capable of providing these important inputs. Further, it is necessary to have adequate inspection steps and to have regular test samples made at various stages. It is normal to collect test samples from the actual foaming operation.

In reporting the result of a test or analysis made in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'.

Indian Standard

CODE OF PRACTICE FOR THE APPLICATION OF POLYURETHANE INSULATION BY THE *IN-SITU* POURING METHOD

1 SCOPE

1.1 This standard defines the requirements of the materials, and methods of application of foamed *in-situ* polyurethane for thermal insulation of storage tanks, vessels, columns, exchangers, piping, flanges, valves, etc. It covers general installation procedures including some important interface data to be resolved between agencies to ensure proper quality of work.

1.2 This standard does not cover application of polyurethane by in-spray method, which would be covered in a separate publication.

2 REFERENCES

The following Indian Standards are the necessary adjuncts to this standard:

IS No.	*Title*
3069 : 1965	Glossary of terms, symbols and units relating to thermal insulation materials
7240 : 1981	Code of practice for industrial application and finishing of thermal insulating materials at temperatures from −80°C to 40°C (*first revision*)
7413 : 1981	Code of practice for industrial application and finishing of thermal insulating materials at temperatures above 40°C and up to 700°C (*first revision*)

3 TERMINOLOGY

For the purpose of this standard the definitions of the terms, symbols and units given in IS 3069 : 1965 shall apply. In addition, the following expressions which are specific to this standard are defined.

3.1 Foam System — Appropriate formulations of the polyisocyanate (or A-stream) and polyhydroxyl compound with foaming agents, catalyst and other additives (or B-stream) specially selected for the intended application.

3.2 Starting Time or Cream Time — Period of time from mixing of components to the point when the foam starts rising. This is indicated when the mixture attains a creamy appearance.

3.3 Tack Time or String Time — Period of time from mixing of components to the point when the foam surface has just started to become adhesive. This is determined by checking the mixture with a needle and drawing out a 'string'.

3.4 Rise Time or Swelling Time — Period of time from start of mixing of components to the point when the foam has risen to its maximum volume.

3.5 Polyurethane Foam (PUR) — A rigid cellular plastic material formed by the catalysed reaction between polyisocyanate and a polyhydroxyl compound (polyol) with a foaming agent which is normally a chlorofluorocarbon gas. The foam shall be composed substantially of urethane linkages which are basically straight chain structures.

3.6 Blasting — The process of cleaning the surface by impingement of abrasive particles propelled at high velocity upon the surface to be cleaned.

3.7 Coating or Covering — Protective materials applied over the polyurethane foam for absorption of ultra violet rays, and for water shedding.

3.8 Inplace Density — The weight per unit volume of the cross-section of foam from substrate to exposed surface including all skins (or surfaces).

3.9 Core Density — The weight per unit volume of a single layer of foam excluding skins that may be formed.

3.10 Poured *In-Situ* Rigid Foam Insulation — A method adopted for complicated shapes for minimizing the number of joint or for strengthening the structure to be insulated by pouring (or injecting) liquid components of PUR into a cavity made by fitting a permanent or removable shuttering around the equipment, where in the mixture reacts chemically to form an expanding foam, filling the cavity fully and setting to form a rigid foam insulation. This is also known as foam-on-foam or layer by layer application of rigid foam insulation.

3.11 Spray Applied Rigid Foam Insulation — A method of insulating large areas in a short time where the PUR foam system is sprayed on the surface to be insulated to form a foam insulation rising freely outwards from the surface.

4 INSULATION SYSTEM REQUIREMENTS

4.1 Cladding

When weather proof cladding of sheet metal is selected, it is recommended that it be installed as a "permanent shuttering". It should be placed and installed around the equipment and piping securely using application practice described in **4.1.1**.

4.1.1 Coated galvanised steel or aluminium sheetings are normally recommended for external cladding. Plain metal sheets of specified thickness are used for pipes, elbows, flanges, valves, etc, and corrugated sheets of specified thickness and corrugation pattern are recommended for tanks, equipment, etc.

> NOTE — When used for permanent shuttering, sheet metal thicknesses are to be selected not only to withstand service conditions but also to withstand foaming pressures which are developed. Suitable external hoop bands are also necessary.

4.2 Spacers

Spacers are required to achieve uniform thickness of insulation all over the surface. Fabrication and installation of spacers should not cause any damage to the equipment. Polyurethane foam blocks of properties compatible with those of main insulation should be used.

4.3 Adhesives

Spacer blocks should be fixed on the tank with use of an adhesive compatible with polyurethane and the protective paint (if any) on the equipment surface.

4.4 Flat Metal Band

This is used as the anchoring for sheet metal and is placed over a row of spacer blocks around the equipment and secured. These bands shall have a minimum metal thickness of 2 mm and width of 25 mm, 30 mm, or 40 mm based on the circumference of the equipment. For strength considerations galvanised steel is preferred.

4.5 Metal Sealer

Cladded overlapping joints (circumferential as well as longitudinal should be sealed by a continuous bead of metal sealer. This should be carefully selected and applied to resist leakage of the liquid foam system and to prevent excess of the expanding foam.

4.6 Mastic Sealer

After completion of the foaming process, holes necessary for filling should be sealed by mastic sealer.

4.7 Hoop Bands

Before starting the foaming process, hoop bands should be provided outside the cladding sheet all around the tank at a specified vertical spacing. When these bands are to be left in place, they should be designed to provide adequate securement to the cladding agains. wind forces. When these bands are provided for construction only, they should be selected to withstand pressures developed by the internal foaming process.

4.8 Sheet Metal Fastening System

These would consist of self tapping stainless steel screws and aluminium blind hole rivets used for fastening longitudinal as well as circumferential joints of cladding. Spacing of such mesurements shall not be more than 100 mm.

4.9 Surface Preparation

After erecting a properly designed and fabricated scaffolding around the equipment, pipe, etc, the surface to be insulated should be wire brushed and cleaned and one coat of a suitable polyurethane compatible paint should be applied before starting the insulation. Thickness of paint film and application procedure shall be according to the customer's normal standards.

5 SELECTION OF FOAM SYSTEM

5.1 A wide range of foam systems are available which produce foams of various densities, suitable for different temperature applications and exhibiting different horizontal burning characteristics, etc.

5.1.1 Suppliers of chemicals are to be consulted for the specific systems suitable to meet the specified properties of foam.

5.2 The selections are normally made based on laboratory tests and many field parameters, such as:

a) The application equipment used;

b) The ambient temperature and relative humidity;

c) The quantity of chemicals injected in each shot; and

d) The preheat of chemicals/pressure of injection; all of which have pronounced effect on all the properties.

5.2.1 For the above reasons, it is recommended that in cases where the supplier of the foam system and the application contractor are different, the latter should be consulted or kept informed about the foam system selected for application.

5.2.2 Similary, the supplier of the foam system should also be provided with full information pertaining to the application, such as:

a) Temperature limitation of the insulation system versus operating design temperature of the equipment/piping to be insulated;

b) Dimensional stablitiy under simulated operating conditions;

c) Fire rating required/specifications to be met;

d) Application conditions including environmental conditions at the proposed time of work;

e) Past history of similar application, if any, linking laboratory values with actual field experience;

f) Compressive strength;

g) Adhesion to substrate, compatibility with surface finishes such as paints. Coating and varnishes; and

h) Thermal conductivity required.

5.2.3 Recommendations of the supplier in regard to storage temperature of chemicals, application methods and precautions, the maximum safe period of storage (shelf life), etc, should be scrupulously followed by the applicator. Application of foam system in contravention of manufacturer's instructions and use of foam system after expiry of its shelf-life are not advisable.

6 HANDLING OF FOAM SYSTEM MATERIALS

6.1 Materials should be stored in accordance with the recommendations of the chemical supplier.

6.2 The supplier should deliver the chemicals to the site in unopened standard commercial containers bearing the label of the manufacturer with the following information:

a) Indication of the source of manufacture;

b) Name of the contents;

c) Net weight of contents;

d) Lot or batch number;

e) Recommended storage temperature range;

f) A 'caution' label indicating strict instructions for handling and storage temperature range;

g) Mixing instructions;

h) Listing agency label, if applicable, and certificate of conformance;

j) Expiry date or shelf life; and

k) Recommended maximum pot-life after opening of container.

6.3 Containers should not be opened until ready for immediate use.

6.4 In the case of bulk shipments, the chemicals can be transferred to appropriately sized, clean dry containers, or containers that had previously contained the same material. Care should be taken to exclude moisture pick up during transfer operations and, where necessary, containers can be blanketed with an inert, dry atmosphere.

7 NOTE TO THE DESIGNERS

7.1 *In-situ* polyurethane insulation provides a large number of advantages to the designers of low temperature equipment and piping system. The following are listed as guidelines:

a) The pour-in-place system affords a very high degree of adhesion between substrate and insulation and, between the insulation and the cladding unless a releasing agent or a separation layer is specifically provided to break the bond. Hence, systems can be designed for capability to withstand high windloads and disbonding forces.

b) The arrangement for support to cladding done through a hoop band, supported, on adhered, non-conducting rigid spacer of polyurethane itself renders provision of elaborate welded support redundant.

c) There are many equipment which direcly support external provisions, such as platforms and ladders. The common practice is to anchor these provisions to equipment through metal lugs and wooden blocks. These normally represent condensation risk areas which are normal cause for initiation of insulation break down in conventional applications. If these anchors are designed to allow unhindered provision of three times the thickness of the insulation, totally foolproof insulation treatment can be provided using *in-situ* pouring technique.

d) Supports for piping need simple detailing to render them totally resistant to insulation failure. It is recommended that correct practice be followed in that location.

e) It is important to identify areas where expansion / contraction patterns are subject to sudden change. In these areas, a simple provision of bonded mineral wool insulation duly laminated with a foil would render the treatment accomodative to these requirements.

f) Care is needed to ensure that sufficient offset is provided in nozzles, manhole projections, gauge assemblies and fittings mounted on equipment to accomodate the overall thickness of insulation treatment. Where corrugated sheeting is used, additional space for depth of corrugation should be available.

8 GENERALISED PROCEDURE OF INSULATION BY *IN-SITU* METHOD

8.1 All the surfaces to be insulated should be cleaned with wire brush and coated with approved polyurethane compatible paint.

8.2 Location of spacers should be marked on the painted surface. It is recommended that these spacing should not be more than 450 × 450 mm. The spacer block should be cut from preformed insulation of the same thickness and at least 100 × 100 mm size.

8.3 Adhesive should be applied on the surface and spacers should be fixed on the surface.

8.4 Each row of spacers should be secured and tightened with cladding support with metal-band straddling each spacer in that row.

8.5 Cladding should be fabribated with specified grooves and beads to meet the overlap specifications.

8.6 Cladding should be fixed on spacer bands with galvanised screws or blind hole rivets with an overlap of not over 50 mm in both longitudinal and circumferential directions and these points should be sealed with approved elastomeric sealent.

8.7 Pour and rise holes where necessary should be drilled and measured quantity of chemicals should be poured. In all other areas pouring is carried out from the top opening of the annular space.

8.8 Pour and rise holes should be taped off at the time of application and eventually sealed with weather proofing mastic.

8.9 All completed works shall be cleaned to remove any spills of chemicals and all metal jacketing joints examined for gaps.

8.10 Where the application involves use of a removeable shuttering and eventual application of vapour retarders and weather barriers, there shall be a layer of release agents provided to the inner surfaces of the shuttering to prevent adhesion of foam to them. These release agents are to be selected appropriately.

8.11 After application of the insulation using removeable shuttering method, the rest of the application procedure shall be in accordance with IS 7240 : 1981 and 7413 : 1981 depending on the application temperature involved.

9 MEASUREMENTS

9.1 Measurements of the completed work shall be carried according to the provisions of the IS 7240 : 1981 and IS 7413 : 1981 depending on the application temperature involved.

10 MINIMUM REQUIREMENTS FOR APPLICATION EQUIPMENT

10.1 In contrast to the production of moulded parts or semi-finished products in a factory, the processor of *in-situ* polyurethane foam receives raw materials and carries out the precise chemical reaction and gives the final shape at site.

10.2 The requirements for meeting and mixing machines are dictated by the following basic considerations:

a) The drums to store and pumps to disperse the chemicals to the metering system should be safe and moisture must be excluded at all costs.

b) Good temperature control is necessary both before metering the chemicals and while conveying them from the metering system to the mixing head in the delivery system.

c) Precise control over chemical delivery quantities combined with versatility of adjustment in the ratio of the through puts of the chemicals is an essential prerequisite for any polyurethane foaming machine. Moreover, it is necessary to have adequate extra capacity to ensure that all situations encountered at site can be handled without restraint.

d) Optimum mixing quality, which has bearing on the cell structure is achieved by very precisely designed mixing chamber where the two components come into contact with each other.

e) The delivery of the chemicals from the mix system to the annular cavity has to be in laminar flow condition.

10.3 The above precision levels are achievable only with specially designed machines which not only meet these requirements but, at the same time are rugged enough to withstand construction site conditions.

11 MINIMUM REQUIREMENTS FOR FACILITIES AT SITE

Consistant with the operations involved in this method of insulation application, the following facilities are considered essential.

11.1 Chemical Storage

It is essential that a covered and well ventilated space be allocated to store the chemicals. Under no circumstances should the drums be kept in the open or water be allowed to come in contact with the chemicals.

11.2 Chemical Blending and Formulation

It is essential that the chemicals be soaked for at least two days prior to blending at a temperature of 24°C. This calls for an air conditioned space capable of holding two days consumption of chemicals plus the area required for weighing, blending and filling into the containers to be taken to site.

11.3 Enclosures for Chemicals and the Foaming Machine

The locations of these enclosures are to be arrived at in relation to the layout of the equipment and piping routes to be insulated. Covered temporary sheds or mobile covered trailers are needed to fulfill this requirement.

11.4 Scaffolding and Platforms

Unlike other insulation applications, *in-situ* polyurethane application requires attention to be paid to proper scaffolding design. As explained earlier, this method involves deployment of precision equipment and supervising/inspecting manpower at the various levels of work. Moreover, in some instances, the entire foaming equipment may need to be hoisted and operated at high elevations. Scaffolding is at times custom designed to ensure that no compromises results for want of proper access to the operating areas.

11.5 Quality Control Facilities

In keeping with the norms applicable to such work where quality is generated at site as it were, there is need to install equipment to carry out routine checks. In works of smaller size, where deployment of the full compliment of facilities is not justified, the decision of the contractor shall be with the consent of the purchaser.

12 PROTECTIVE GEAR AND FIRST-AID REQUIREMENTS

12.1 Consistent with standard precautions necessary while handling volatile chemical substances, it is necessary that the following are available at site and are used during operations:

a) Protective work clothes;

b) Safety glasses preferably with side protection;

c) Protective gloves which are impermeable to liquids;

d) Chemical resistant work shoes;

e) Water containers and dispensers to wash parts of the body which may accidentally be exposed to spills; and

f) Bottles of eye cleansing lotion in case of accidental splashing to the eyes of personnel.

12.2 In general, it is recommended that a high level of house-keeping standards be insisted upon in the work area. Clothing should not be allowed to get saturated with chemicals and, if this should happen, proper washing be carried to prevent even the remote possibilities of skin contact and irritation caused thereby. Work places must be well ventilated at all times.

13 ROUTINE TESTS

13.1 Routine tests which are to be carried out at site on hourly samples are listed in the suggested quality control chart.

13.2 Representative samples of the applied insulation are to be collected at intervals as agreed to between the contractor and the purchaser and compliance with the requirements set out in this standard are to be verified in laboratories selected mutually.

IN-SITU POLYURETHANE FOAM INSULATION QUALITY CONTROL CHART

Name of Project :

Name of Contractor :

Day &
Date..................................

Details of Surface to be insulated

Piping ....Dia, Length ....
Equipment (Tank/Column/Exchanger) Horizontal/Vertical
Dimension :
Thickness of Insulation:

Operating temperature :

Insulation and Site Condition Data

1. Method of application (Pour/Inject):
2. Specified average core density kg/m^3:
3. Location (Under roof/Exposed):
4. Weather Conditions
   a) Air Temp, *Max* °C... .... *Min* °C...............
   b) Relative Humidity %
   c) Weather condition Clear.............Cloudy..............
5. Foam System (application condition)
   Component A= °C Component B= °C
6. Surface Preparation:
   a) Cleaning method used:
   b) Details of painting (if any):

Cladding

Material for Cladding (Material/Gauge):

Sealing material used:

Duration between Cladding and Foaming...........days/hrs

Foaming Machine details

Make...... ....

Batch No. Identification	Cube Sample No.	Core Density kg/m^3

Samples drawn Size 1 No.
Size 2 No.

Visual Physical Observations

Cube Sample Number	Foam Pour Structure	Foam Stability at Room Temperature after 48 hrs

Name of Foaming Machine Operator :

Name of Inspector :

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